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AN  
A N A L Y S I S  
OF THE  
ELECTRICAL FIRE, &c.

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AN  
ANALYSIS  
OF THE  
ELECTRICAL FIRE;  
SETTING FORTH, FROM THE  
LECTURER's OWN EXPERIMENTS,

THAT

It neither ATTRACTS, nor REPELS; nor is ATTRACTED, or REPELL'D, by POINTS; or, any other Way, is not MATERIAL nor INHERENT in BODIES, nor in the CLOUDS, &c.

TOGETHER, WITH AN  
ACCOUNT  
OF AN  
UNCOMMON EFFECT OF LIGHTNING,  
AND  
DISSERTATION ON THUNDER CLOUDS;

SHEWING,

That Thunder is not caused by such Clouds being impregnated with MINERALS; but, by FROZEN OR COLD Ones, coming into a WARM Atmosphere.

DEDICATED TO  
Dr. F R A N C K L I N.  
By THOMAS KIRBY.

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PRINTED FOR THE AUTHOR.



TO THE

## R E A D E R.

THE proper application of Philosophy is, or should be, to contemplate the operations of Nature, in order to promote the welfare and happiness of mankind; while the Student keeps this in view, if he fails in the pursuit, his design is laudable; as studying the works of Creation, is the grateful tribute of a rational Being to his CREATOR; but, this by no means infers, that the limited understanding of mankind, is equal to, or  
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capable of, investigating the infinite wisdom of the Almighty ; nor is the way to this knowledge, by adhering to partial, or particular opinions. For truth is general ; and, like the influence of the Sun, the more it is enquired into, the more perfect it will be found, and therefore cannot be too strictly scrutinized ; provided, the Examiner does not so far degrade himself as to cavil, or use sceptical arguments.

Most of the following remarks, as near as I can recollect, were made upward of thirty years ago, when itinerant Lecturers on electricity were frequent ; chiefly from what they advanced ; but not being designed for publication, they were in separate detached pieces, in the most desultory manner : however, as the greatest part of the arguments replied to, are to be found in different parts of the

London

London Magazines for the year 1746; those pieces, are now put, as well as I can, together, and, am in hopes, without any other assistance, they will be sufficient to evince the truth of my assertions in the Title Page; for, although numbers of volumes have been since published on the subject; I cannot charge my memory, with having read so much as a single line in any one of them; nor do I think it of the least signification, whether I have, or not, as it is universally agreed, that the electrical fire has a power of attraction, and repulsion, is material, &c. which are the matters in question; therefore, if what I have to say, invalidates all the arguments herein contained, I am under very little apprehensions from any thing that may have been said since.

It is amazing to find how implicitly men copy and follow each other; the sanction of Sir Isaac Newton's name has alone been sufficient to establish the most erroneous opinions; who, himself, was but a copy of the \* Ancients; who, themselves, were wrong in almost every thing relative to the processes of our terraqueous globe.

I need only mention the cause of the precession of the equinoxes, which that gentleman attributes to the figure of the earth being a spheroid; and which, if Plutarch is to be credited, has been a subject of enquiry ever since the days of Numa; and probably, for ages before. Julius Cæsar, Pope Gregory, and our own Astronomers, have all foil'd themselves at it. In my *Essay on Criticism*,

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\* Vide, An Enquiry into the Origin of Modern Discoveries.

I published the real cause, and sent one of the pamphlets to the Royal Society; and, although it is eighteen years since, the truth of it has never been acknowledged by any one, that I have heard of, excepting, my unknown friend, Philomath; and yet, I call upon every professor of Astronomy in the kingdom, any way to make it appear, that it is not a perfect investigation of the subject: but some, who have seen it, perhaps, are ashamed to own it, as it explodes all the spheroidal nonsense of Sir Isaac, and with him, all the capital astronomers in Europe; some of the most eminent of whom, were abroad ten or a dozen years, at an enormous expence, to measure a degree of a meridian; in order to be certain, whether the earth was a spheroid, or not: which, in the front of my Essay, I shewed, could not be done with the desired accuracy;

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and, if it could, that they did not take the proper methods for doing it.

In that Essay, I presume, I have also said enough on the Theory of the Tides, to evince its absurdity, perhaps more than it deserves; which Theory, is all Sir Isaac's own; he could have no assistance from the ancients: for, Aristotle himself, it is said, could not discover the cause of the several tides in the streight of Negropont; which, as he was so near the place, one would think he could not have miss'd.

The Tides are far from being the principal in the moon's influence over the earth; they are rather a result, or consequence from it; her dominion immediately concerns the whole globe, was she to stop, or deviate from her path, but a very few

few hours, the inhabitants must all inevitably be destroyed.

It is disagreeable to be carping at, and censuring, what others have done; but I find it indispensably necessary to point out their errors, in order to prepare the way for the truth of my own assertions: I don't mean those only mentioned in my Essay, but others, not touched on by either Ancients or Moderns, which I have not the least objection to making public; nay, so far from it, that it has always been my desire, 'till I was convinced of its impracticability, without a Mecænas to usher them into the world. But it is so many years since my pamphlet appeared, that perhaps the times are changed, and I may find the way more open and clear. The first impression, where matters were but slightly touch'd on, was attacked by the Monthly Reviewers, in one of the most malevolently designed criticisms, against

Science,

Science, that ever disgraced literature; but, as the statute of limitations, does not extend to these matters, I may possibly hear from those gentlemen again.

I cannot here forbear mentioning the making discoveries near the Poles; not that I think it impracticable to get there, but, it is necessary, our navigators should be apprized of the danger of the attempt; as I may safely venture to assert, that whoever fees either of the Poles, or gets within three or four degrees of it, must never expect to see the habitable parts of the globe again.

CHATHAM,  
November 1777.

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E R R A T U M.

In page 8, line 24, after electricity, add—and the wire twisted in the spring is the conductor.

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A N A L Y S I S  
O F T H E  
E L E C T R I C A L F I R E.

ELECTRICITY is said to be derived from *electrum*, (amber,) although I cannot see much analogy between the attraction of amber and the electrical heat or fire : indeed, amber, sealing-wax, &c. when rubb'd, will attract straw, sand, and other light bodies ; yet, it is not clear to me, that they do it so much by heat, as by the rezinous, or some other occult quality in them. And we find, the magnet does the same, in a more extraordinary manner, on steel and iron, without being rubb'd, or heated at all. However, it must have a name, and Electricity seems to have a technical sound ; which Electricity is caused by friction, and produces real fire ; which fire, it is positively asserted, has, at the

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same time, both an attractive and repulsive quality ; (a contradiction in the nature of things;) nor, is it clear to me, that it has either of them. The experiments, indeed, may sometimes have appearances, that countenance such an assertion, which, on examination, may prove otherwise ; for, it should be considered, that the subjects, such experiments are made on, are most of them so light, and susceptible of agitation, that the least perturbation in the air affects them. And also, that the electrical fire emits itself like a light wind, which drives the air before it, and sufficiently agitates it for that purpose ; for fire and air, I apprehend, cannot subsist together ; therefore, when light bodies are laid on any thing, and held up near the barrel, the communication of the fire from the barrel to the object, causes a small vacuum between them, and consequently, the pressure of the air, inclines such object to the barrel ; but after it is impregnated, and drawn up, if the friction is discontinued, its gravity causes it to subside, and fall off again. But, if such subject has gravity sufficient to support itself against the emission of the electrical fire, and is laid on, or on one side of the barrel, to receive that fire, I apprehend, there then will be no appearance to countenance either attraction or repulsion.

The reason why leaf-gold is suspended at a small distance from the barrel, I apprehend is, as follows: when such leaf-gold is held within the reach or verge of the electrical fire, there is, as before said, a small vacuum between them; so, that the impulse of the air, at first, inclines the leaf-gold to the barrel; and, when there, by making the friction a little stronger, it is driven off, as far as the wind from the electrical fire reaches; where, from its having little or no gravity, it is suspended between that fire and the air: but the least commotion or disturbance in the air, causes it to fly off; and when away from the influence of the electrical fire, it fluctuates, and subsides, just as the slightest affection in the air directs.

Again, it is said, that "A boy suspended in silken or woollen cords in the air, and being electrified at his head; his feet attracted, and then repell'd the leaf-gold." This is just the same as between the leaf-gold and the barrel, the emission of the electrical fire first causes the vacuum, and the air forces the leaf-gold to the boy's feet; and when there, by adding to the friction, the emission of the electrical fire forces it away again.

Again; "If a man, who is electrified, holds a plate in his hand, with very fine, slender bits of glass, or wire, or little balls of cork, on it; and one, who is not electrified, holds another plate over it, by bringing the upper plate gently down,

“ within 7 or 8 inches of that which is  
 “ electrified, he will find the bits of glafs,  
 “ &c. raise themselves upright; and, as he  
 “ brings it nearer, dart themselves to the  
 “ upper plate, and stick to it.”

The reason, I apprehend is, the bits of glafs, &c. lying on the lower plate, as soon as the person who holds it is electrified, and the upper plate brought within 7 or 8 inches of it, the light wind, from the emission of the electrical fire, raises them upright; seemingly, as if that fire endeavoured to reach as far as it could to get at the upper plate, making them the conductor; and was there no upper plate, nor any thing else in its stead, to stop them, they would be driven quite away, and fall to the ground. But, as it is, when the upper plate is brought near enough, they are forced up, and seemingly stick to it; and, altho' that plate then becomes electrified; yet, by increasing the friction, they still continue up. But if the friction is discontinued, or any other way their fire is discharged, they directly fall into the lower plate again, as if not electrified. And, in this manner, as long as the man, who holds the lower plate, continues electrified, by holding the upper plate nearer to, or farther off, from it, and increasing or decreasing the friction, the bits of glafs, &c. may be made to rise and fall, or dance up and down, as long as the operator pleases.

Again; “ If a quantity of fine saw dust  
 “ is laid on a piece of flat iron, and the  
 “ fame

" same quantity held upon any thing beneath it, within reach of the electrical fire, as soon as the iron is electrified, the quantity above will fly off from the iron, and that beneath, draw up to it."

The reason again, I apprehend is, the quantity on the iron has not gravity sufficient to support itself against the emission of the electrical fire, which disperses the saw-dust, but the quantity beneath is prevented from being driven away; so, that as soon as that fire makes a vacuum, between what the saw dust is held upon, and the iron, the air forces that directly to fly up to the iron. All which are caused by the emission of the electrical fire, and small vacuum it makes; but had the bodies weight, or were fixed, like those which lightning is mischievous to, there would be neither attraction nor repulsion. Besides, such trifling emissions of fire, in comparison with a ball, or flash of lightning, will hardly bear mentioning; it is somewhat like comparing the effects of a drop of water with those of the quantity which would drown a man, or swim a ship.

And in the aforesaid manner, the emission of the electrical fire may move small glass vesicles round a saucer, which otherwise might have too much gravity to be driven from the conductor, or forced up to it. And a variety of such fancies and tricks may be shewn, which are diverting enough; but, on enquiry, will all appear to be actuated from the same principles.

Again;

Again, " It may as well be said, that a pump causes water, as that friction produces fire." at non sibi as noli as non

Here I must confess, that I really do think, that a pump causes water; nay, further, in my opinion, the maid who fetches water to clean her rooms, also causes water; or else, poor girl, I fear she would be in danger of being called to an account for the dirtiness of her house. But surely this cannot seriously be advanced as a parallel, or any way similar to the electrical fire being, or not being, inherent in bodies.

Again, " Fire is the *Anima Mundi* of the Ancients." That the genial heat and warmth of the Sun, nourishes and sustains all animals, vegetables, &c. on the face of the earth, I believe, neither Ancients, nor Moderns, have disputed; but, it should be remembered, that we, nor they, can hardly bear the extremities of that. I don't know, what either of us should do, had we real fire in us.

Again, " The sensitive plant has more of fire in it than any other, as when any thing touches it, it imparts a great deal of its fire to the thing by which it was touched. This, I think, a very palpable mistake; for, a light, gentle touch, will not affect the sensitive plant. But, if the leaves and branches are set in motion, they then directly droop, and fall; which, may be done by shaking the pot the plant grows in, without the least contact with any thing. There is something curious in this

*phenomenon.*

*phenomenon.* It appears to me, that when any of the leaves or branches are set in motion, as soon as the vibration of the leaves reach the branch, or that of the branches reach the stem, such leaves and branches begin to droop, and not before. But I cannot see any appearance, or indeed the least necessity, there is for fire in the operation.

Again, it is said, " Many bodies have actual fire in them, as flints, &c."

If in extreme cold weather, the flints, &c. were to be found warmer than other bodies, or more susceptible and ready to take fire, it might give some countenance to this assertion; but, on the contrary, they are not only colder than most other bodies, but less susceptible of taking fire, and yet will strike fire, as well in cold as the hottest weather.

Again, " The natural cohesion of fire, and its propensity to unite, is proved from the flame descending down the smoke, and at some distance lighting the snuff of a candle just blown out."

The reason of this, I apprehend is, although the flame of the candle is off, yet the snuff continues burning, and the smoke from the snuff not being entirely divested of the inflammable parts of the tallow, when a flame is held in it, those inflammable parts being nearest to the tallow, the flame communicates itself downward, through the snuff,

snuff, and relights the candle ; and the more fire there is in the snuff, the more susceptible, and ready it is to take fire. But it should be remembered, that a large snuff may be also rekindled while the inflammable parts of the tallow are in motion, by blowing on it, without the help of another flame, which certainly is not by cohesion, for wind and flame are different things ; therefore, the question is, would there be any of this cohesion if the snuff was quite cold ? To which, I believe, I may venture to answer in the negative ; for when the fire is out of the snuff, and the tallow cold, I doubt the cohesion is all over ; and I also believe, it will be difficult to find any other bodies which have less of this cohesion, or any other way sympathizing with fire, than flint and steel.

Again, “ By flying a kite, the clouds are found to have electricity, (meaning fire,) in them.” My answer to which, is, that 'tis the friction on the kite which causes such electricity ; for was another kite, every way as alike as possible to that which was flying, to be suspended at the same time, and in the same clouds, if no friction was on it, I dare say there would be no electricity from it ; but granting that the clouds really had fire in them, it does not follow that the kite, from whence the electricity proceeds, should also have it ; nor, was fire inherent in bodies, can I see any reason for the

the kite's having more of it in the clouds, than on the ground, especially as the clouds must be most damp; and, that height in the air does not encrease the electricity, is very plain; if it did, those who pass the Alps and other high mountains would often find themselves in danger of being set on fire; when on the contrary, what they feel and suffer is from cold.

Not many years since, I saw an Electrician produce a little box with a couple of small balls, made of the pith of a rush, fastened in it by two hairs; which balls he let fly in the wind, to know whether the clouds had electricity or not: if they flew near each other, he said the clouds had electricity; if they separated, none; which I think was one of the most puerile and trifling conceits I have met with; for although I never was present at the flying of any of these kites, yet I believe I may safely venture to pronounce, that in proportion to the wind, they will have the same electricity when there are no clouds, as when there are ever so many; nay, in my opinion, when there are fewest clouds there will be most electricity; which may be put to a fair trial, by flying the same kite, at one time in clear, and another in cloudy weather; at both times fastening a weight to the end of the string, for the kite to move, and see that the force of the wind at each time is nearly alike; besides, this contradicts one of their

own assertions, viz. that electrical experiments succeed best in clear weather.

As to flakes of fire flying about in the November storm, a gentleman who was living when these remarks were made, and could remember it, assured me, that in that storm, the lead was blown from Gillingham church, and found near a mile distant from it. So that when it is considered, that flying a kite in a moderate wind, will produce an electrical shock, it cannot be so much wondered at, that the friction of such a storm in many instances, might produce flakes of fire; but it is so long since that happened, that little is to be depended on, from what can now be said on it.

The wisdom of the Creator is so striking in making a difference between the elemental fire, and fire acting on matter; that I cannot pass it without notice. The elemental fire gives a shock and impregnates all electrics that comes within its verge, or reach; which shews its action as an instrument of divine vengeance; but it no sooner sets fire to any thing, than those qualities are taken away. For was fire acting on matter to impregnate bodies, it would be certain death to come near a fire-side; as the greatest heat the operators venture to excite, is by no means equal to that of a sea-coal fire; but otherwise, the elemental fire, and fire acting on matter, have some properties nearly alike; as they not only both of them prey on that first which

which is easiest and soonest consumed, but have their different degrees of heat; for, as in the elemental fire, that which will set fire to spirits or gunpowder, will not to paper; nor that which will do it to paper, to wood, &c. So, on fire acting on matter, that which will set fire to a match, will not to a shaving; and that which will do it to a shaving, will not to wood, &c.

It must be also observed, that the elemental fire, when it meets not with matter to act on, soon extinguishes; was it not so, a ball or flash of lightning would be much more mischievous than it is. But fire acting on matter, continues often, till what it acts on is consumed; and may be increased, extinguished, or led from one thing to another, with very little trouble or danger; which plainly shews it designed for the common uses of mankind.

### *The Electrical Fire is not Material.*

**I**T is the generally received opinion, that the electrical fire is material, although its passing through the most solid and compact substances, without affecting them, or itself, one would think, might evince the contrary.

It is also asserted, that the heat of the Sun is material; indeed it is very well

known, that a small portion of the Sun's heat contracted into a focus by a burning-glass, will set fire to matter; but surely that does not any way intimate, that the fire itself is matter; according to my ideas of it, the elemental fire preys on, and consumes every substance it meets with, in proportion to its intensity, and their different qualities; and consequently was it material, must destroy itself in embryo.

It is also to be observed, that the reflection only, of the Sun's heat into a focus, from concave mirrors, may be made to melt, or vitrify the most obdurate metals, and surpass all other known heats, without in the least affecting those mirrors; which reflection, most certainly cannot be material; therefore, for my own part, till I am shewn better reasons to the contrary I conclude that fire is not material, and content myself with calling it the element of fire, well known by its common and proper name, FIRE.

Nor do I see sufficient reason to conclude, that fire is not really generated from friction; the argument that when fire is produced from flints, each spark is a calx; proves as much against, as for it; for whether the fire is generated from the stroke, or awakened, and called forth from the flint or steel by it, either way the spark would be calcined; and the particle of steel (if any) melted. But in an electrical operation which produces much more fire than such a single stroke

stroke ; there are no particles of either flint or steel, to calcine, or melt; besides it contradicts one of the first assertions, viz. " that " the electrical fire arises not from the " glass-ball, the leather, the tube, nor the " hand; but, from the air they are moved in," which comes very near to a virtual confession, that it is generated from friction; and will come nearer if it is granted, that the air has no fire in it.

Again it is said, " That a point attracts the " electrical fire." I think it is past controversy, that the electrical fire emits itself more forcibly towards a point, than a broader surface ; it being the nature of fire to prey on that which is easiest and soonest consumed, for altho' an iron point will not take fire so soon as one of wood, or other more combustible substance ; yet, the effort of the fire towards it, appears to be the same, as may be seen in an electrical experiment, where the emission of the fire in such a small portion, (as it must do towards a point,) naturally causes it to extend itself farther than when issued in a larger quantity ; and consequently, more or less, in proportion to the fineness of the point or breadth of the surface that receives it. And if one person holds a point towards the barrel, and another a broader surface, at the same time, at the same distance, and of the same metal, I make no doubt, but it will be found, that he who holds the point will receive

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an electrical shock, when the other will not; although according to the laws of attraction, the largest body should attract most. This is also countenanced from the action of the flame of a candle, or any other culinary fire; either of which will set fire to a point sooner than a broader surface; so, that every way, the action appears to be in the fire, and not from any attraction in the point.

And as a point is more susceptible of the electric fire; so, on the other hand, it appears to be less retentive of it: for when any thing which has a point is impregnated, if the fire is excited to a sufficient degree, it will discharge itself at that point; and when excited to a violent degree (if the conductors would stand it), I apprehend would do the same from the ends of any bodies; especially if they were long and tapering. Had I ever been master of an apparatus, I don't know whether I should not have endeavour'd to have made more discharges than one at a time, by having more points than one; as a difference in the sharpness or bluntness of them, perhaps might cause a difference in the times of the discharges. But it would have required a very violent continuation of the friction, and a dangerous degree of fire.

That a ball, or flash of lightning in passing thro' the air, will set fire to any thing in its way; and if what it meets with is large enough, may be stop'd and exhausted, or

or its course altered, is very natural to conclude; but that it will repel, or attract, or what is still more unnatural, repel, and attract the same body, at the same time, is ridiculous; the only inference I can draw from the lecturers, and their experiments; is, that they mean (if any meaning), that as such balls of lightning pass thro' the air, when they come near any thing, they repel and drive themselves from it, and afterward attract and bring themselves back again.

Experience shews, that light thunder-clouds, or those high in air, seldom or ever hurt any thing; and, indeed, by much the greatest part of the lightning which appears to us, flashes and soon extinguishes. But that which is mischievous, is thrown forth, and disengaged from the cloud, and in its passage thro' the air, strikes and surrounds every thing in its way, and is often too large and dangerous to be resisted; consequently points, and small bodies, will take fire soonest in proportion to their electrical qualities; nor can it be thought that conductors will prevent its operating, as they probably will be among the first things destroyed, it not being uncommon when lightning has struck a house, to hear, that the wires of bells have been melted when no other mischief has been done.

*An*

*An uncommon effect from Lightning.*

SOON after the intrenchments were made to secure the Dock-yard, and magazines of stores, here at Chatham ; I was awakened about two or three o'clock in the morning, by a very loud clap of thunder, just as if a cannon had been fired over my head ; on rising and looking out at the window, it appeared to me as if the cloud had discharged itself at once, for there was little or no appearance of there having been any thunder at all ; the next day a sentinel, whose duty was that night on the hill, came round the town, and said he was struck down quite senseless with the lightning, but knew not how long he laid, and when he came to himself, found he had received no particular hurt ; he produced one of his shoes, which had the greatest part of its upper leather torn off, in a most extraordinary manner ; the handle of his bayonet had visibly been cemented to the barrel of his firelock, altho' they were then broke asunder ; the blade of the bayonet had a hole melted through it, near the middle, about the size of a pea, and the scabbard not hurt, altho' it was on.

From

From all which I infer, that the same ball, or flash of lightning, wherever it comes, operates on different subjects, according to their different electrical qualities. What I would have understood by this is, that, as there are electric's, and non electric's; so, without doubt, there are different degrees of electric's, and steel and iron perhaps, in one of the first classes; as in this instance, steel appears to be more an electric than leather; else, how should the blade of the bayonet have a hole melted through it, without affecting the scabard which was on it?

How far this electric quality, in different bodies, has been ascertained, is unknown to me, as I don't remember ever to have heard it mentioned. But if it has not been adverted to; in my opinion, one method for doing it, might be by having conductors made of the different substances, to be assay'd, every one of them of the same dimensions; and, as far as it can be done with safety, using the same degree of friction on them all; till one, or more of them set fire to spirits, and that, or those, which did it soonest, to be the first class; and then using a greater degree of friction on those which were left, till one or more of them set fire to the spirits, for the second; and by using more friction for the third, and so on. And I dare say, amber, sealing-wax, sulphur, &c. would be found

in a very inferior class ; and if so, it might be an argument, that their power of attraction is not analogous with the electrical fire ; besides, you may rub glafs in the manner amber is rub'd, a long time indeed, before any attraction is produced from it ; altho' a gentleman now living, assured me, that he once produced a slight shock, from rubbing on a gun barrel.

The reason why the shock is greater from a coated phial, than one which is not, I apprehend is, the quantity of electrical fire, which would impregnate the whole, was it a solid body of glafs, is pent up in the thin substance of the phial, and confined by the tin from communicating itself inward, as it otherwise would do, so that all its force is thrown outward ; but was there no tin on the inside, the fire probably would extend toward, if not meet and unite from all parts around, to the inside center, nearly the same as if it impregnated a solid body. Therefore, in this essay, or trial ; in my opinion, the most eligible method would be, to use solid conductors ; or if not, to take particular care, that they are not only of the same dimensions, but the same bore.

But to return to my subject ; in the above mentioned affair there is no appearance of the steel, or iron, having eluded, or diverted, the lightning ; for the man was struck senseless, and the upper leather torn off his shoe,

shoe, which again leaves room to think, that different parts of the same ball, or flash, has different degrees of intensity; else, why should the leather be torn off the shoe? and the scabard of the bayonet, altho' it was on, not affected?

It is many years since; but, I remember the time, when Friendsbury church steeple, and the Chatham hulk's mast (the former covered with shingles) were both set on fire by lightning, it was said, by the same flash, altho' there was near half a mile distance between them; but then the church steeple stands on a very high ground, and the hulk is on the water; and the land and water between them low, with no buildings to intercept.

And I have seen a ship's mast shivered in a surprizing manner by lightning; at the same time the seamen said, there was a ball of fire passed between decks, without hurting any thing else; which shews its intensity was abated before it came there.

### *A Dissertation on Thunder Clouds.*

THAT thunder is produced from cold clouds coming into the warm, seems very obvious; as, in our warm seasons, we often see them coming on for some time, before

fore they burst over us; but I cannot see the necessity there is for nitre or sulphur in the operation, any more than in an electric explosion, where neither of them are, or can be, concerned. Nor did I ever hear, that either of them, joint or separate, without charcoal, would cause such an explosion. But granting, that they would, I much doubt, whether the water, which such clouds are composed of, would not prevent it; as we find, even gunpowder itself, is hindered from taking fire by water; and I have as little opinion of such clouds being impregnated with the effluviae of the pyrites; for, if such effluviae will take fire in water, how happens it, that all other clouds have not the same effect? For there is as much, nay, more, rain, in hot weather, without thunder, than with it. That many spring waters are impregnated with minerals is past controversy. But, that the clouds are, in my opinion, will admit of dispute; for, snow water, which certainly is from the clouds, is said to be the purest of all others; if that is true, rain carefully received, must be nearly as pure, as snow is but rain frozen: and, that its being warmer before thunder, is caused by sulphur, or any other mineral, I cannot join opinion in; as it is clear enough to me, that such heat is caused by the approach of the thunder cloud, which generally coming against the wind, repels the heat of the weather, and prevents it from dispersing, as it otherwise would.

That

That friction produces heat and fire from electrical bodies, is very certain; the reason why it does, I apprehend, must remain a secret, 'till the sympathies and antipathies of inanimate substances, are much better known, than at present. But how this friction can possibly happen in a cloud, which generally dissolves itself into rain, is to me an insurmountable difficulty. And, it should also be remembered, that fermentation will produce fire, as may be seen not only by mixing alkali's and acids, but damp haystacks, moist hemp, &c. and, in short, every thing, which, by its action, produces heat; a sufficient increase of that action will produce fire; which fire, I make not the least doubt, is of the same quality as the electrical; for abstracted from what it acts on, the element of fire will always be the same, which way, or from whatsoever it is produced.

The most likely of any thing which occurs to me, to account for thunder and lightning, is the expansion of those heavy, black clouds, which produce it, by heat; altho', as yet, there are no experiments sufficient to prove it; yet, it is in some measure, countenanced, from a bladder fill'd with common air, being laid by a fireside, where it soon swells, and bursts; which must cause some commotions within it, not improbably similar to the *fermentation, or ebullition*, hereafter mentioned.

Thun-

Thunder clouds being composed of hail and snow, the outsides perhaps cased round with ice, which prevents them from separating, and dispersing. By their own density, or weight, will always force themselves into a warm atmosphere. And their being in, and surrounded by it, very probably, may cause them to ferment, and burst into the explosions of thunder and lightning.

I have often endeavour'd to make observations on such clouds; and once on a fine, calm, sun-shine day, saw one coming on from the northward; at first it appeared not very large, but, as it came nearer, increased in magnitude, which I imputed to natural perspective; at last, the under part was nearly as low as the earth; it reach'd very high, and extended a great way East, and West; the part next my sight was in a *ferment or ebullition*, agitating to and fro, in various directions, which might also add to its magnitude; soon after small flashes of lightning appeared, followed by a loose scattering of hail, with large drops of rain; after that a large flash of lightning, with a proportionable clap of thunder, and very heavy shower of rain, which thunder and rain (the thunder with intervals) continued about three quarters of an hour; when the cloud appeared to be exhausted and dispersed, and the weather cleared up, and was fine again, only cooler, and pleasanter, than before

before it came on; so that the continuance of the thunder and rain, very clearly appeared to be, in proportion to the bulk and largeness of the thunder cloud.

In this operation, I think it not improbable, but, that after the first explosion, the warm air, by degrees, penetrated and made partial inroads into the cloud, and by that means caused those parts of it to ferment and burst into a second \* explosion, and when the air was once got in, more followed, and penetrated into other parts, and continued so doing, till the whole was blown up, broke, and dispersed. But I cannot mention this as conclusive, because my observations were not so perfect as I wish'd. And, altho' I made other attempts, yet the rain or distance of the thunder cloud, generally frustrated my endeavours; however, what I have done, perhaps, may lead others, to observations, which may either disprove or confirm the truth of mine; but thunder clouds have such a variety of forms and changes in their appearances, that it will be difficult to describe any of them, with much precision, excepting, such very large, and visible ones, as this I have mentioned.

It may be objected, that clouds, only from cold climates, and high mountains, can be frozen. But my opinion is, that

\* In some of the explosions, clouds, edged with fire, seem'd to burst forth, which had an exceeding fine appearance.

at great heights, in the atmosphere, it always freezes, if there is any thing to freeze, which may be admitted as another argument, that fire is not material; for out of reach of the reflection of the sun's heat from the surface of the earth, I apprehend, the temperature of the air; or rather of the æther, or vacuum, is nearly the same, as if that grand luminary gave no heat at all; agreeable to my assertion in the *Essay*, viz. that "light and heat, where there is not any thing to reflect them, has no existence."

### F I N I S.

### E R R A T U M.

Page 7. Last line but one of the *Analysis*, read—*being most*, nearest the shallow, common kind this *analysis* will most easily be followed. But as the two

